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THE POTENTIAL OF LANXIDE CERAMIC AS A MATERIAL FOR PERMANENT MOULDS

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THE POTENTIAL OF LANXIDE CERAMIC AS A MATERIAL FOR PERMANENT MOULDS

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SUMMARY

Small samples of Lanxide SiC/Al_2O_3 ceramic composite have been subjected to thermal shock tests. Cast iron was poured into a water-cooled copper mould with a small sample of the ceramic set into its base. Two grades of the ceramic were tested, one a standard grade and the other a "special" grade with finer SiC particles. After 50 pours, the standard grade developed cracks, whereas the special grade did not. Coating with a ceramic wash prevented cracking in the standard grade. In all cases the surface of the sample in contact with the molten iron was roughened by the melting and extraction of free aluminum present in the ceramic.

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POSSIBILITÉS D'UTILISATION DE LA CÉRAMIQUE LANXIDE COMME MATÉRIAU POUR LA FABRICATION DE MOULES PERMANENTS

par

K.G. Davis, J.R. Emmett, et J.-G. Magny

SOMMAIRE

De petits échantillons de composite céramique Lanxide SiC/Al_2O_3 ont été soumis à des essais de chocs thermiques. On a versé de la fonte dans un mould en cuivre refroidi à l'eau au fond duquel on avait placé un petit échantillon de cette céramique. Deux classes de céramiques ont été mises à l'essai, une classe normale et une classe "spéciale" avec des particules de SiC plus fines. Après 50 coulées, la céramique de classe normale présentait des fissures alore que la céramique de classe spéciale n'en présentait pas. L'addition d'un enduit céramique sur l'échantillon de classe normale a prévenu la formation de fissures. Dans tous les cas, la surface de l'échantillon en contact avec la fonte était rendue rugueuse par la fusion et l'extraction de l'aluminium libre présent dans la céramique.

INTRODUCTION

Environmental regulations associated with the use of sand in foundries are becoming more and more restrictive. Hence the use of "permanent", i.e. re-usable, moulds is becoming increasingly viable. For the lower melting point alloys such as zinc and aluminum, the great majority of castings are now made in metal moulds, and for the copper-base alloys the use of metal moulds is fast increasing. However, nearly all castings made from the higher melting point alloys such as cast iron and steel are still made in sand moulds. The main reason for this is the lack of a suitable permanent mould material. The inherent lack of refractoriness in common metallic alloys leads to limits on their use, and the high melting point alloys such as those of Mo are difficult to machine and very expensive. Ceramic materials offer a possible alternative. However, to maintain production rate a mould must have high thermal conductivity. The only candidate ceramics that meet this requirement appear to be SiC and TiB_2.

Work at MTL, and at other research centres, on moulds made from bonded particulate mixes of Al_2O_3 or ZrO_2 plus SiC showed them susceptible to early failure through cracking caused by thermal shock. Ceramic composites in which SiC particles are infiltrated with molten aluminum which is subsequently oxidized to Al_2O_3 have recently been introduced by the Lanxide company. They are reported to combine excellent strength and good resistance to thermal shock with high wear resistance, and would seem to have promise as mould materials.

The objective of the current work was to obtain a preliminary estimate of the suitability of Lanxide ceramic for use as a permanent mould material for the higher melting point alloys.

PROCEDURE

Small samples of two types of Lanxide SiC-Alumina ceramic were provided for testing*. They were of two grades, a "standard" grade with coarse SiC particles and a "special" grade with finer particles. For the tests, a small rectangular piece of the ceramic, approx. 22 mm by 15 mm by 5 mm, was cut in a diamond wheel saw. It was placed in a cavity machined in the base of a water-cooled plate mould made of pure copper (see Fig. 1), and held in place using a cavity about 6 mm larger than the sample and filling in the gap all round with CO_2 sand. The mould was poured with cast iron, at about 1350°C. The castings were removed after approx. one minute, and the temperature of the top surface of the ceramic sample was measured with a thermocouple probe. The temperature of the bottom surface of the sample was measured by a

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* The ceramic samples were supplied by the Lanxide Corporation, Tralee Industrial Park, Newark, DE. 19711, USA, to Mr. Bruno Kindl, who is associated with the Department of Metallurgical Engineering, Queen's University, Kingston, Ontario.

fixed thermocouple, the mould being re-poured when this latter temperature dropped to about 35°C. Three Lanxide samples were tested, with about 50 castings being poured over each.

Variations in test procedure included coating the ceramic surface, and directing the incoming stream either directly onto the sample or onto another area of the mould base. Maximum temperatures at the bottom of the mould varied from 150 to 300°C, and those at the top of the mould after casting removal from 450°C to 700°C. The casting usually came off the ceramic sample cleanly, but periodically the sample came out with the casting and had to be re-set into the mould.

In all the tests, after one or two runs free aluminum in the ceramic was seen to have melted and been forced to the surfaces, leading to small extrusions of aluminum and holes where aluminum had exited. Figure 2 shows the bottom surface (opposite to that in contact with the poured iron), after 50 cycles, for the standard ceramic (Test 1 below).

TEST 1: STANDARD CERAMIC

For the first 12 tests, a zirconia-base alcohol wash was sprayed on the mould between pours. For 6 tests the sample was coated along with the mould, and for the other 6 it was uncoated. The sample was then removed. Some cracking was noted. It was re-installed, and 20 more castings made, this time with acetylene soot coating. Finally, 20 more castings were made with zirconia wash on the sample.

Result

Two distinct cracks had developed across the sample surface, one of which could be seen on the side surfaces and was clearly quite deep. The surface was pock-marked, with some glassy material adhering to certain areas.

TEST 2: SPECIAL GRADE CERAMIC WITH FINER SIC

No coating was applied to the sample. After 50 castings had been made there were pock marks associated with aluminum extrusions, and a general roughening of the surface with some glassy patches. There were no cracks.

TEST 3: STANDARD CERAMIC

In this test the sample was always coated with the zirconia wash. Results were similar to those from test 2, with no major cracking.

Figure 3 shows the surfaces at the end of the first two tests. After test 1, the surface of the ceramic in contact with the iron was very lightly abraded to remove any debris, and one of the cracks was photographed (Fig. 4). It is clear that the crack ran through individual SiC particles, rather than between them.

CONCLUSIONS

Lanxide ceramic has promise as a permanent mould material for the higher melting point alloys. However, surface cavities left when molten aluminum escapes will tend to be enlarged with repeated use, and the mould life will be limited to the stage where penetration by the poured metal into such cavities will cause the casting to stick to the mould and so cause damage when removed. Mould life can be enhanced by coating the mould, but this negates one of the potential advantages of using ceramics over metal moulds, namely the possibility of eliminating the need for mould washes. The finer grade ceramic was markedly superior. If a grade can be developed that is free of aluminum metal, at least at the surface, greatly improved mould life may be expected.

One might note that molten cast iron dissolves SiC readily. It is therefore probable that there will be a critical temperature where dissolution of the SiC phase, with associated sticking of the casting to the mould, will become serious. However, the current tests show that if such a critical temperature exists it is greater than 700°C.

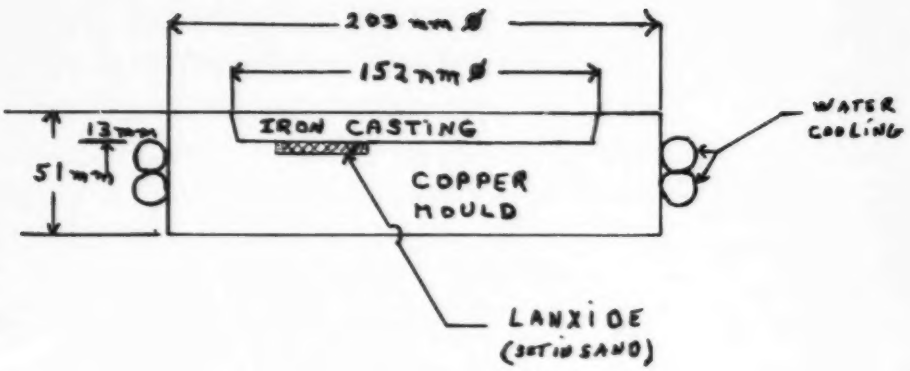
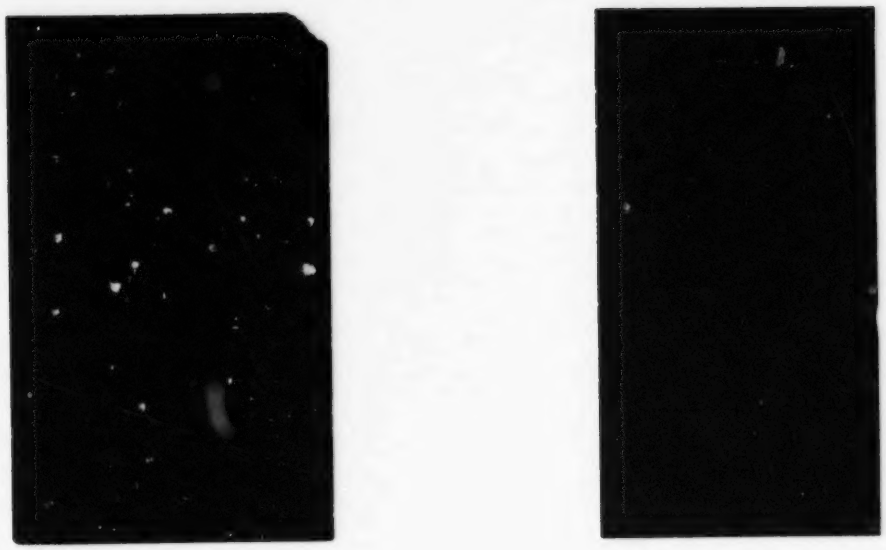


Fig 1. Schematic of the test mould.

Fig 2. Bottom surface of the sample of standard grade Lanxide ceramic after Test 1 (50 pours). X3. (neg. 20257)



(a) Standard ceramic, Test 1 (b) Finer grade ceramic, Test 2

Fig. 3. Surfaces of the Lanxide ceramic samples at the end of testing. X3. (neg. 20258, 20259)

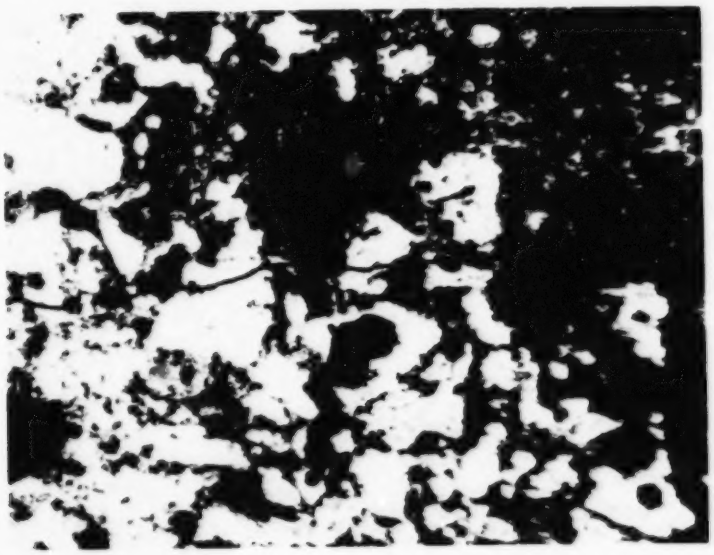


Fig. 4. Crack in the standard ceramic at the end of Test 1. Surface lightly abraded before picture taken. X 10. (neg. 20260)